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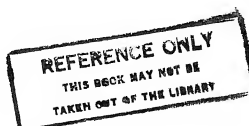
This document is designed to help employers and employees develop appropriate arrangements in their individual undertakings. The HSC commends this document to the foundries industry.

Jard Collection

First report on clothing to protect against molten metal splash hazards in foundries

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Preface

These notes of guidance concern the selection, use and maintenance of protective clothing in situations where there is a risk of injury from splashes of molten metal. They are the agreed, preliminary recommendations of a working party authorised by and appointed through the Foundries Industry Advisory Committee, and were formally ratified by the Foundries Industry Advisory Committee at its meeting on 8 November 1984.

The working party has met on eleven occasions since its formation in July 1982, and it is intended that its work should continue.

Introduction

1 The Foundries Industry Advisory Committee (FIAC) gave its working party two main tasks: first, to consider the nature of the risk of injury from molten metal, and second, to make recommendations about suitable levels of protection which might be afforded by clothing. Although it is recognised that there are factors of fundamental importance which still must be explored further, the FIAC is nevertheless conscious of increasing pressure from within the industry for guidance on what protective clothing might be suitable for those exposed to molten metal hazards. Consequently the FIAC is anxious to make known to the industry its recommendations to date, albeit that these may be limited in scope.

2 The results of tests carried out by HSE on the resistance of various fabrics to molten metal have been

considered along with, to the extent that information is available, accident experience within the foundry industry. Consideration of other factors, such as comfort and acceptability to wearers and maintenance aspects of clothing, has yet to be developed to any really objective or scientific standard, but from present knowledge it is nevertheless possible to make some basic observations on these matters.

3 This report discusses the various aspects of protective clothing which should be of concern to employers and employees, and provides the information they need to make an informed decision about the likely risks involved in their particular activities and the types of clothing most suitable for their individual circumstances.

Legal requirements

4 Although the Foundries (Protective Footwear and Gaiters) Regulations 1971 reflected the pressing need for protection of the feet and lower legs - the most common sites of injury from molten metal - other areas of the body were still left vulnerable, there being, at that time, no legislation requiring protection for the main part of the body. Because of concern at the number and frequency of serious burn injuries, the Health and Safety at Work etc Act 1974 (HSW Act), with its all-embracing duties placed on employers, is seen at present as the means for correcting this legislative deficiency, although further specific regulations may well be made in the near future employing the concept of whole body protection.

5 With the development of textiles which provide resistance to molten metal it has been possible to interpret the general provisions of the HSW Act realistically to meet the problem of molten metal burns in the foundry industry. The search for suitable clothing has been given added impetus by the recognition that gaiters have certain drawbacks, and that alternative forms of protection for the lower leg may well be desirable.

6 The HSW Act (Section 2(1)) requires employers to ensure, so far as is reasonably

practicable, the health, safety and welfare of all their employees while at work. The provision of molten metal resistant clothing is required if the likely risk of injury to the employees outweighs the costs to the employer of providing the clothing; in almost all sectors of the foundry industry, it does. Indeed, successful legal action has already been taken against employers for failing to provide protective clothing. (Employers will find that by devoting a little time and thought to an objective appraisal of the risks within their own factories and to the selection of the most appropriate protective clothing, the costs will be greatly reduced. Impulsive purchasing, made without sufficient consideration, will usually only result in wasted money - and the problem will remain unresolved.)

7 Provided that the clothing with which they have been issued is suitable, and is backed up by adequate supervision and training, individual employees have a duty to wear it. Section 7 of the Act requires employees to take reasonable care for their own health and safety at work. However, employers must be able to show that the garments are suitable, and this document is intended to offer guidance on the factors involved in 'suitability'.

Assessment of risk

8 At the outset, the employer must make a considered assessment of the various levels and types of risk which are present in his foundry. Employees should be

categorised according to the risks to which they may reasonably be expected to be exposed. Factors which should be taken into consideration include

- (a) the quantities of metal being handled in furnaces, ladles, moulds etc, and whether slag is present;
- (b) the likely forms in which metal splashes may occur (eg whether in the form of a concentrated stream such as from breakouts or spills from ladles or moulds, or whether more in the form of a shower of droplets, such as occurs with water/metal explosions, or normally as part of the process);
- (c) the parts of the body which are likely to be affected by the metal splash (eg the whole body or just lower legs or arms);
- (d) the proximity of the various employees to the likely source of danger;
- (e) the frequency and duration of exposure;
- (f) the foreseeability of injury, and
- (g) the site history of burn accidents and molten metal splash incidents.

9 In many foundries it will perhaps be helpful to think in terms of three broad categories of risk, although more or fewer categories may be appropriate, depending upon circumstances. Employees who may be exposed to large streams of metal, for instance furnacemen, are usually regarded as being at the higher levels of risk. Casters are often regarded as being at a more medium level of risk, with perhaps points of high risk on the body (eg legs). People who are more remote from the molten metal, such as some labourers perhaps, can be regarded as being in the lower risk category. Managers, visitors, metallurgists and maintenance workers can be at any level of risk, depending on their proximity to the molten metal and the activity going on at the time. The case for maintenance workers must be stressed in particular, since they are often close to the source of danger when something wrong or unusual has happened and when, consequently, the process may be less stable than normal.

10 The protection requirements of the various employees will be determined from the assessment of risk. This detail in the assessment is important because, while it is obviously necessary to make sure that the protective clothing is sufficient for its intended purpose, most protective clothing will, by its nature, cause some degree of discomfort or inconvenience to the wearer and it is therefore sensible to minimise this by choosing the lightest clothing that the hazards of the particular job will allow. Aspects of comfort and acceptability of clothing are discussed later.

11 In respect of the foreseeability of whole-body splashes, accident experience suggests that these are most likely to occur under the following circumstances:

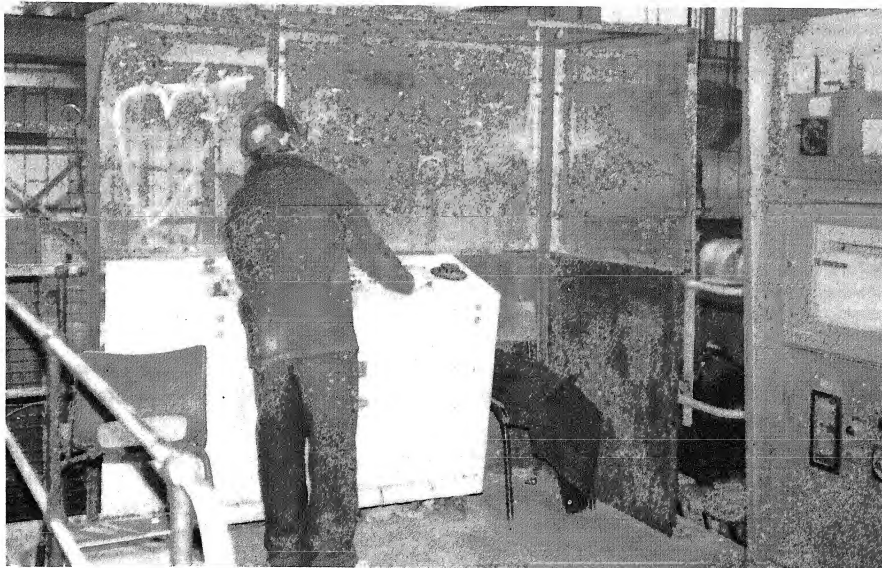
- (a) work at furnaces of all sizes, particularly where additions are being made to the molten metal, where scrap or ingots are being charged and where objects, receptacles or instruments are being inserted into the molten metal;

- (b) experimental work, or during commissioning of new plant, or when different or new procedures are being tried (the testing of new dies would be included in this category);
- (c) continuous and semi-continuous casting;
- (d) sand casting, and
- (e) where metal is being carried overhead.

It should be borne in mind that not just production workers may be at risk in these circumstances. Supervisory staff, members of management, laboratory staff and metallurgists may be present, and perhaps particularly so when the risks are higher than usual - eg when faults or problems develop, when something new is tried, or when measurements and samples are being taken.

12 It should be stressed that no wearable garment will guarantee full protection against an extensive, concentrated stream of metal. Clothing should not be regarded as a substitute for other basic precautions, such as segregation of molten metal areas from main thoroughfares or other types of activity, or routing overhead ladles away from people. Equally, protection from the risk of molten metal splash may not always call for protective clothing; careful use of screens can eliminate the risk during certain operations or for certain sectors of the workforce.

13 In some foundries, splashes to specific parts of the body may be clearly identifiable as the most foreseeable type of accident in certain jobs. In such cases it would be valid to concentrate on localised high-risk protection; depending on the risk, this could be combined with whole-body protection to a lesser standard. In other types of foundry, burns to lower legs and hands are universal and commonplace, but they would appear to represent the extent of the foreseeable risk to most people. An example would be many of those carrying out repetitious production work at hot chamber diecasting machines where guards, incorporating screens, closely surround the dies; in such a case the ejection of metal from the bottom of dies seems to be the most likely event and lower leg protection should therefore be the priority. (It should be remembered that the provision of gloves and gaiters or longer boots are currently specific requirements in regulations, but otherwise, additional protective clothing might reasonably be limited to just the lower half of the body.)



Example of effective use of screen to protect against molten metal splash at induction furnace.

Resistance of fabrics

14 In the selection of protective clothing the fabric's resistance must be the first consideration. There are three main properties to aim for: resistance to adhesion of molten metal, resistance to penetration by molten metal and resistance to ignition by the hot metal.

Ignition

15 All common clothing materials burn at temperatures well below the melting point of even aluminium, so there is a foreseeable risk of their bursting into flames on brief contact with most molten metals. The danger is greatest for the lighter and more flammable fabrics such as fine cotton, polyester, viscose, acrylic fibre and nylon, a fact tragically illustrated by a recent incident in the USA when several men died from burns caused by the flaming of their everyday polyester/cotton clothing after an explosion in an aluminium works. Clearly, an important requirement for protection against molten metals must be that clothing should have a degree of resistance to ignition; this may be assured by using fabrics conforming to BS 3120: 1959 "Performance requirements of materials for flameproof clothing" or to a newer standard, BS 6249: 1982 "Materials and material assemblies used in protection against heat and flame".

16 Leather, and wool fabrics above 650 g/m² in weight are inherently flame resistant while the lighter wools and all cottons have to be chemically treated. All these materials will ignite after sufficient contact with molten metal but the time to ignition will be greater than for ordinary clothing.

Adhesion

17 Molten metals may adhere to some flame resistant materials, causing injury through heat transfer. Compliance with BS 3120 or BS 6249 is therefore no guarantee of a material's ability to protect against molten substances. To overcome this, a more specific method of test has been developed: BS 6357: 1983 "Assessment of the resistance of materials used in protective clothing to molten metal splash". The various materials have been tested by pouring a given quantity of molten metal on to them and by observing the effects of the metal on both the material and an underlying skin simulant.

18 Heat transfer through the testpiece is assessed by observing the damage to the PVC skin simulant placed behind, and in contact with, the testpiece. Different weights of molten metal are poured on to successive specimens to determine the 'molten metal splash index'

for the material. This can be thought of as the maximum weight of metal which the material can withstand and still prevent undue damage to the skin simulatant. The higher the molten metal splash index, the more resistant is the material.

19 The molten metal protective materials which are commonly available fall into three main categories: *leather*, *wools* and *cottons*. Various materials are also available with an aluminised outer surface. Test results have given indications of the relative performance of the materials.

20 The performance of materials with respect to adhesion of molten metals is an important consideration; the results are summarised in Table 1 for examples of steel and iron slag, molten iron, copper, and aluminium. (Where a range of performance is indicated, this means that different results were obtained for different samples of the same type.) The entry for untreated cotton shows why denim gives some protection, provided it does not burst into flames from contact with trapped molten metal. It should be noted that the aluminised materials and leather are not suitable for full suits (unless intended to be worn for no more than about 20 minutes at a time) because they are far too hot. However they can be used for localised protection - eg in the form of aprons or gloves or gaiters.

21 Some guidance can be given about protection against the more common metals handled in the foundry industry. In the case of molten *iron* and *aluminium* (at normal working temperatures), it has been possible to derive molten metal splash indices for various materials. The results are shown in Tables 2 and 3. The materials have been categorised according to the values of the molten metal splash index, as an aid to selection.

22 Accidents where concentrated pours of molten metal occur are the most difficult to protect against, owing to the length of time that molten metal might be in contact with the clothing. Tables 2 and 3 give approximate times for which the various materials can be expected to give full protection. They are very short. In the case of molten iron, only leather resists for more than a second. This suggests that any wearable clothing is unlikely to be totally effective against this type of incident, but it can certainly help greatly to minimise the extent of injury. The need for prevention by other means, such as screening, should be remembered.

Slags

23 Many slags are low density, glassy substances which adhere strongly to clothing materials, particularly cotton fabrics treated with phosphorus based flame retardants, such as Proban®. Essentially, the lower the density of the slag, the more likely it is to adhere.

Wool should be worn when molten slag is being handled.

Steel

24 Heavyweight melton wool suits (or materials giving equal levels of protection) are required in all primary risk areas in steelworks. Wool must also be used where substantial quantities of steel slag are present because it is the only material with consistent shedding properties.

Iron

25 Against molten iron, all types of material mentioned in Table 2 are suitable. Heavy cotton fabrics treated with the phosphorus based flame retardants compare favourably with wool fabrics of similar weight, but lighter weight cotton materials do not. The adhesion which can mar the performance of the lighter cottons is overcome in the heavier ones, since they are woven in a double layer and the inner layer remains relatively intact. Wool, being a more loosely woven fabric, can trap droplets below the surface and this may be the reason why woollen garments, as opposed to cotton, are more prone to spark damage in use.

26 Leather gives a very high standard of protection, and for this reason has been placed in a category of its own. Its use, for protection against pours, should be considered for specific areas of the body. The materials listed in category 2 would be expected to work well against a cloud of molten droplets, such as may be produced in a metal/water explosion. In practice, reasonable protection has also been afforded in this sort of incident by the fabrics in category 3. The materials in category 4 are intended more for welding and cutting applications or for low risk situations in iron foundries.

Copper

27 Performance against molten copper is broadly similar to that against molten iron, except that cotton fabrics treated with phosphorus based flame retardants show slightly improved performance owing to a reduction in adhesion. Wool, on the other hand, seems to allow penetration of droplets of metal. Experience has shown that a cotton jacket of only slightly over 470 g/m² in weight, when showered with molten copper at only 20°C above its melting point, can prevent injury to the wearer, even though the garment itself will be badly damaged.

Aluminium

28 Findings for molten aluminium are given in Table 3. Because aluminium is less penetrating than many other metals, wool garments perform very well and are an obvious first choice. Cotton materials treated with organo-phosphorus flame retardants (eg "Proban®" and "Provatex®") are not suitable because the metal adheres extensively to the cloth. Cotton materials treated with

vapour phase flame retardants such as "Caliban®" perform much better, although some slight adhesion still occurs. These latter materials may be appropriate

if they are of sufficient weight, and could be expected to protect against a shower of molten aluminium.

Table 1 Adhesion of molten substances to protective clothing materials

Material type	Molten substance				
	Iron at 1400°C	Steel slag	Iron slag	Copper at 1280°C	Aluminium at 800°C
Leather	Non-extensive	Extensive	Extensive	None-specks	None-extensive
Wool	None	Slight	None	None	None
Wool treated with Zirpro® flame retardant	None	Slight	None	None	None
Cotton	None	None-extensive	None	None	Slight
Cotton treated with Proban® flame retardant	Specks-extensive	Extensive	Extensive	None-specks	Extensive
Cotton treated with Caliban® flame retardant	None	Extensive	None	None-specks	Slight-severe
Aluminised materials	None	Extensive	Slight	None-specks	Specks-severe

Note:

"Extensive" indicates patches of adhesion larger than 10mm across

"Severe" indicates patches of adhesion larger than 5mm and not more than 10mm across

"Slight" indicates spots of adhesion not more than 2mm across

"None" indicates no observable adhesion

Table 2 Performance of materials against molten iron at 1400°C

Material type	Material weight (g/m²)	Molten metal splash index (g)	Approximate time of molten metal Contact (secs) (see para 21)	Remarks
Category 1				
Leather	780-2000	> 500	> 1.20	
Category 2				
Cotton moleskin treated with Proban® flame retardant	620-640	180-195	0.75	Some adhesion
Wool melton (to BSC MM1 specification)	660-700	155-185	0.70	Best results obtained for tighter woven fabrics
Wool melton treated with Zirpro® flame retardant (to BSC MM2 specification)	590	140-275	0.70	As above
Category 3				
Wool twill treated with Zirpro® flame retardant	460	130	0.65	
Cotton moleskin treated with Proban® flame retardant	570-590	100-190	0.60	Some adhesion
Category 4				
Cotton denim treated with Caliban® flame retardant	450	90-130	0.55	Lower figure after 30 washes
Cotton beaverteen treated with Proban® flame retardant	420-440	80	0.55	Some adhesion
Wool twill treated with Zirpro® flame retardant	280-300	70	0.50	
Cotton beaverteen treated with Proban® flame retardant	360	65	0.50	Some adhesion

Note:

Proban® is a phosphorus based flame retardant

Caliban® is a vapour phase flame retardant

Table 3 Performance of materials against molten aluminium at 800°C

<i>Material type</i>	<i>Material weight (g/m²)</i>	<i>Molten metal splash index (g)</i>	<i>Approximate time of molten metal Contact (secs) (see para 21)</i>	<i>Remarks</i>
Category 1				
<i>Leather</i>	780-2000	>400	>1.80	
<i>Wool melton (to BSC MM1 specification)</i>	650-700	>400	>1.80	
<i>Wool melton treated with Zirpro[®] flame retardant (to BSC MM2 specification)</i>	590	>400	>1.80	
<i>Wool twill treated with Zirpro[®] flame retardant</i>	460	365	1.60	
Category 2				
<i>Wool twill treated with Zirpro[®] flame retardant</i>	280-300	150-165	0.70	
Category 3				
<i>Cotton treated with Caliban[®] flame retardant</i>	450	110-180	0.60	Lower figure after 30 washes
Unsuitable				
<i>Cotton treated with Proban[®] flame retardant</i>	360-620	≤30	≤0.10	Extensive adhesion

Note:

Proban[®] is a phosphorus based flame retardant

Caliban[®] is a vapour phase flame retardant

Types of garment and design features

29 Protective garments are available as separate jackets and trousers, one-piece overalls, aprons, shirts and knee-length coats, but not all fabrics are made up into all these garments. Leather, for instance, is usually restricted to aprons (as well as gaiters and gloves). As production workers will almost always require protection against the continual risk of burns to the lower leg, knee-length coats should not normally be considered for them. However, such coats can be invaluable for use by managers, supervisors, visitors and in some cases laboratory staff, when their exposure to risk is of very short duration, and the risk is more from a molten metal explosion or metal splash than from their proximity to a possible low-level breakout or overfilled mould etc. The ease of slipping on a coat means that such people are far more likely to take advantage of the protection in practice than they would be if expected to change into overalls or trousers.

30 In any workplace a number of considerations should be weighed up in deciding whether to select

jackets and trousers or overalls. The relative thermal comfort of each type has yet to be investigated; this may prove to be a major factor. Otherwise, overalls, having fewer potential trapping points, are perhaps more likely to shed molten metal, but on the other hand can take longer to remove in the event of extensive splashing. It may be the case that a higher standard of protection is required for the lower half of the body than the upper half, or that the rate of wear and tear on clothing is greater on one half than the other; in such cases jackets and trousers may be indicated. However, there is always a risk of jackets not being worn when necessary or left unfastened, in which case overalls have an advantage.

31 Whatever garment is chosen, it should present minimal trapping points. Because of the very short time for which clothing materials resist molten substances it is very important to design garments to minimise entry of splashes and avoid trapping points. The best designs incorporate the following features:

- (a) overlapping seams on the outside should be downward facing and lockstitched,
- (b) jackets should be long enough to cover the tops of the trousers even when the wearer is bending over,
- (c) external pockets on jackets and overalls should be covered by flaps 20mm wider than the pockets to avoid tucking in,
- (d) reinforced protection should be considered for the crotch area, shoulders and collar,
- (e) quick release fastenings should be provided to enable rapid removal in an emergency but care should be taken to cover metal parts and
- (f) trouser bottoms should be wide and long enough to overlap the top of the footwear and should not have turn-ups.



Protective jacket and trousers made from Proban® treated cotton cloth.



Protective jacket and trousers made from melton wool cloth.

Comfort and acceptability to the wearer

32 It is of major importance that made up protective garments can actually be worn at all times that the risk from molten metal splash is present. It is known that many garments which are currently commercially available are often discarded by the wearers on the grounds of being too hot and uncomfortable to wear and increasing levels of fatigue. Although there is evidence from custom and practice, the working party is seeking to establish on objective grounds what types of protective clothing it might be reasonable to expect people working with molten metal to wear, given the levels of physical activity and hot environmental conditions within their industry. The findings will be covered in a later report.

33 From the point of view of the wearer, *thermal comfort* is undoubtedly the most important quality required of any clothing. Particularly if the wearer is doing hard physical work, discomfort and even medical problems will result if the design of clothing or the type of fabric restrict the loss of heat from the body. Because molten metal protective clothing (which, it should be remembered, will normally be worn in conjunction with boots, gloves and face screens) must necessarily enclose the whole body, the properties of the clothing fabric and design are of paramount importance in determining the rate of loss of body heat and the consequent achievement of thermal comfort. As a general rule each part of the body should be protected with the lightest garment commensurate with the hazard.

34 At this stage some basic guidelines can be given on thermal comfort:

- (a) Totally covering garments of leather or aluminised fabrics are unlikely to be able to be worn because the *impermeability* of the materials does not allow the body to rid itself of excess heat. They have a role to play in very high risk situations where exposure is necessary for only a very short time (say about 15 to 20 minutes at most, depending on the level of physical activity) and for not more than a few times a day. Recovery between each spell of work should be in a cool environment.
- (b) Clothing worn underneath the protective garment will increase the *insulation value*. In hot weather, undergarments should be removed as necessary - but not the top, protective garments. Underclothing should not be of synthetic, flammable materials.
- (c) The ability of air to pass through the whole garment is of major importance in removing excess heat from the body, and is probably of even more significance than the permeability of the fabric where the work is physically active. Again it is hoped to investigate which types of design most encourage this *air exchange*, but for the time being it is perhaps sufficient to stress the importance of the *fit* of the garment. Tight fitting or tightly belted clothing should be avoided. The supplier of the clothing should be able to provide a sufficient range of sizes and expert individual fitting to ensure each person has fairly loose garments of the correct size.

- (d) The more permeable a fabric is to water vapour and air, the more easily sweat will be able to evaporate and cool the body. Generally, the woollen fabrics tend to be more permeable than the cotton ones, (but it may be that the greater stiffness of cottons, clinging less to the body, permit more exchange of air - see (c) above).
- (e) Given equal permeability, thinner materials are generally less insulating and therefore more comfortable than thicker materials. A lightweight wool twill will therefore tend to be more easily worn than a heavy melton cloth.
- (f) Should it be considered necessary, on the basis of risk, for very insulating or impermeable garments to be worn, the effects of heat stress can be avoided by limiting the duration of work and allowing adequate rest pauses. It may be necessary to take medical or other professional advice in establishing the pattern of work.

35 Other factors relating to comfort and acceptability which should be taken into consideration in the choice of protective clothing are

- (a) not impeding movement or mobility
- (b) avoiding possible irritation to the skin and
- (c) ensuring safety appearance. If there is a need for high visibility clothing, bright, luminous colours can be incorporated into the design.

Use, provision and storage of clothing

36 If the garments are not properly used or worn, they will be of little use. Investigations of severe burn accidents in steelworks in recent years have revealed the folly of leaving jackets undone. Provided garments have been carefully selected, taking into account comfort requirements, it will be necessary to ensure correct use of clothing by the system of line supervision.

37 Apart from 'occasional' users (eg management, visitors) all people requiring protective clothing should be issued with their own personal garments. More than one garment per person is necessary to allow for regular laundering. Where clothing is provided by a rental company each employee is generally issued with three items so that a spare garment is always on the work premises.

38 The employer should hold sufficient stock of an adequate size range to provide an immediate re-issue when a garment in use becomes unwearable. He should also have an agreement with his supplier for back-up

stocks to be available at short notice in cases where garments are purchased outright. This is not an area for cost cutting.

39 New clothing should be issued from stores which are open during the working hours of the foundry areas, so that damaged clothing can be replaced immediately. With shift working in foundries the stores may not be open at all working hours but there should nevertheless be arrangements for access to the new stock.

40 The protective clothing should be stored in a place where it will not become unduly contaminated with dust and dirt. Changing facilities, with somewhere to keep personal outdoor clothing, should be available. Natural fibres (wool and cotton) should always be stored in an area which has some ventilation and heating so they do not get damp. Washing areas are often the only places where employees can leave their clothing (sometimes in lockers) but as these areas generally have a high moisture content, heating and ventilation are therefore essential.

Maintenance, inspection and laundering of clothing

41 While the need to provide protective clothing against molten metal hazards is generally accepted in most foundries, there is a regrettable tendency for the commitment to end, prematurely, at the point of issue. It is self evident that if clothing is worn for eight hours a day in hot, dusty conditions, it will rapidly become contaminated with dust, including carbon dust, oil, grease, perspiration and body acid. Additionally, there will inevitably be damage from wear and tear on the clothing, and spark damage from the process. All this will have two main effects: first, the clothing will tend to become increasingly unacceptable to the wearer on hygiene grounds, and second, the degree of resistance to molten metal will be steadily reduced. Either way, the protective value of the clothing will tend to be diminished; it is therefore essential that there is positive, proper maintenance.

42 Essentially, the maintenance requirements will involve regular laundering, inspection of garments for damage, and arrangements for immediate replacement or repair, as appropriate.

43 From the point of view of the mechanical resistance of the material to molten metal, most of the tests which are carried out to determine resistance involve new and unworn fabrics. The more a material deteriorates the more unpredictable will be its performance in the presence of molten metal. There is clearly a need for more work to be done on the effects of daily wear and tear on the performance of fabrics, and in the definition of criteria for deciding the maximum useful life of a garment. However it can be stated at this point that only by setting up a system of regular laundering and inspection can the employer ensure that the garments in use are, in fact, serviceable.

44 People responsible for inspecting garments should have received instruction about what they should look for. When a garment is found to be damaged it should either be returned to the manufacturer or contract cleaner for expert repair, or be replaced.

45 Regular cleaning and repair, undertaken by rental service companies or local industrial laundries, should ensure that most soiling and defects will be removed. Cotton fabrics should be cleaned with suitable detergents (not soap) and a wet washing process; this has the advantage of removing body soiling as well as dust and dirt. Wool fabrics should always be professionally dry cleaned. However a possible disadvantage, of heavyweight wool clothing in particular, is that the dry cleaning process does not remove body soiling, and a continuous build-up in the fabric results, causing a harshness which increases the irritation from the cloth. The employer should insist that employees change protective garments regularly - the frequency being determined by the number of hours that the clothing is worn for work. This will at least reduce the build-up of body soiling not removed by dry cleaning.

46 It is important to ensure that the correct laundering process, as specified by the manufacturer, is carried out. If it is the garment will retain its full protective qualities. Wool fabrics and phosphorus-treated cotton fabrics have shown negligible deterioration after repeated laundering cycles. Even the cotton fabrics treated with the non-phosphorus based flame retardant, which showed a little deterioration in tests, were still quite serviceable for foundry use after 30 washes.

47 It is disturbing to find that a large number of employers have not yet made any arrangements for laundering or maintenance. In such cases, employees are forced to do the best they can by themselves. Serious deficiencies in the protective qualities of the clothing can result, and, indeed, it can even become positively dangerous to wear. Fabric damage and split seams remain unrepaired, while the garments may be wrongly laundered - that is, if any cleaning at all takes place. It is difficult, it not impossible, to wash the heavy clothing in modern domestic washing machines, launderettes rarely permit the washing of industrially soiled clothing and the charges in high street dry cleaning shops are so high as to discourage any regular dry cleaning.

Durability

48 Durability of clothing in use is a factor which has yet to be explored in detail, from the point of view of both protection and cost. Generally, satisfaction is expressed with the durability of both woollen and cotton clothing in most sectors of the industry, but it is accepted that cotton stands up to wear and tear better than wool.

In some copper works where there is prolonged exposure to high levels of radiant heat, problems have been reported with melton wool garments: the fabric appears to dry out excessively, becoming friable, and disintegrating after a short time; the problem does not appear to occur with cotton materials.

Conclusion

49 Although it is recognised that some aspects of molten metal protective clothing have yet to be fully investigated, it is considered that work is nevertheless sufficiently developed at this stage to provide useful guidance to the foundry industry. Further, it would seem both prudent and timely to respond to the interest in the subject of protective clothing which is currently evident in the industry.

50 The FIAC working party is still anxious to hear the experiences and views of employers and employees within the foundry industry and invites comments and information from users. Comments should be sent to the Secretary to the Working Party, at Health and Safety Executive, West Midlands Area Office, McLaren Building, 2 Masshouse Circus, Queensway, Birmingham B4 7NP.